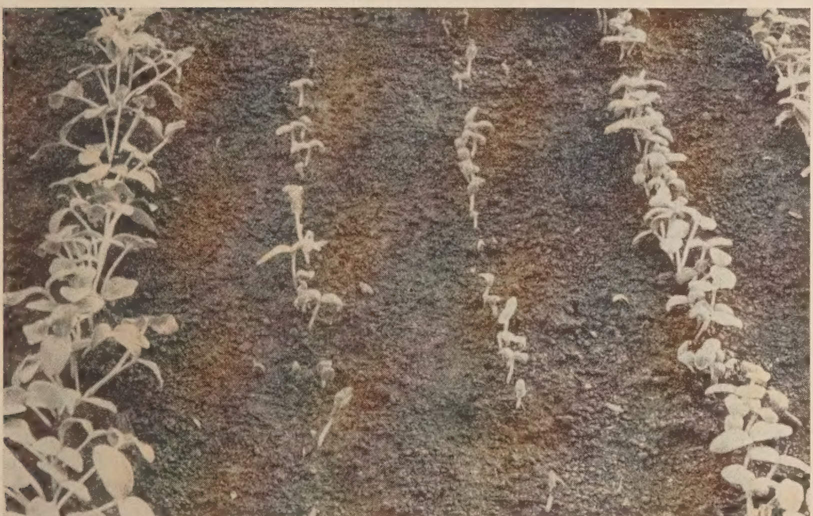
Protectant Seed Treatments for Vegetable Processing Crops

By J. J. Natti and W. T. Schroeder



New York State
Agricultural Experiment Station
Cornell University, Geneva, N. Y.

BULLETIN No. 771 MARCH, 1955

Contents

Abstract

SEED treatment tests conducted during the past 11 years have demonstrated the desirability of protecting seeds of dry bean, lima bean, snap bean, beet, carrot, crucifers, cucurbits, pea, pepper, spinach, sweet corn, and tomato from decay and the seedlings of some of these crops from pre-emergence damping-off.

Not all crops were included in tests every year, nor were the same materials tested each year. Nevertheless, sufficient data were obtained on each crop to point up the better treatments.

Various fungicide-insecticide combination treatments, applied either as dusts or slurries, were tested under a wide range of environal conditions and found effective on seeds of dry bean, lima bean, snap bean, pea, and sweet corn. Exposures of treated or untreated lima bean seed to temperatures in the vicinity of 80° to 90° F, even for a relatively short period of 9 days, weakened the seed and reduced the stand under severe seed decay conditions but did not alter the pesticidal properties of the treatments.

Thiram (Arasan), captan (Orthocide), and dichlone (Phygon) were superior to chloranil (Spergon) as pea seed protectants under severe seed decay conditions when the seed was planted by hand either in the greenhouse or in the field. Chloranil, on the other hand, was equal to, and in some instances, superior to the other three materials when the seed was planted by machine in the field. Chloranil did not retard the rate of flow through grain drills; whereas, the other three materials did. They also increased seed cracking. The retarded rate of flow was overcome by the addition of graphite to the seed or by a higher setting of the seeding mechanism, but the percentage emergence was not improved as in the hand-planted tests.

Some protectant fungicides were more compatible with certain seed disinfectants than others, particularly with seeds of some cucurbits and tomato.

A discussion of the better treatments and a list of the pesticides with their active ingredients are included.

Cover picture shows the comparative influence of Arasan and Phygon in counteracting the detrimental effects of a mercuric chloride soak on seed of National Pickling cucumber. From left to right: Arasan at 0.250 per cent by weight of seed on seed not previously treated; mercuric chloride soak with Phygon protectant at 0.250 per cent; mercuric chloride soak alone; mercuric chloride soak with Arasan at 0.125 per cent. Phygon alone was equally as good as Arasan alone and Arasan at 0.250 per cent on mercuric chloride-treated seed was better than Arasan at 0.125 per cent.

A publication of the
New York State Agricultural Experiment Station
Geneva, N. Y.
New York State College of Agriculture
A unit of the State University of New York
at Cornell University

BULLETIN NO. 771

PROTECTANT SEED TREATMENTS FOR VEGETABLE PROCESSING CROPS

By J. J. NATTI AND W. T. SCHROEDER

Introduction

MOST stocks of vegetable seeds, especially those from reputable seedsmen, are highly viable, vigorous, and free from seed-borne diseases. When such seed is planted, however, it is immediately exposed to a wide range of temperature, moisture, and soil conditions. Included among the latter are soil-borne organisms which can rot the seed or otherwise impair its germination and vigor. Both the seeds and the organisms which attack them are influenced by environmental conditions in the soil. If most, or all, of them favor the seed, good emergence may result in spite of the presence in the soil of the various bacteria, fungi, and other organisms capable of inciting seed decay. If, however, conditions are such that they favor the seed-decay organisms instead of the seed, poor or weak stands of plants may result.

Crops differ in their optimum requirements for good seed germination. For instance, peas may germinate well at a relatively low soil temperature, but that same temperature might delay the emergence of beans to the extent that soil organisms could attack and destroy the seed. Since it is impossible to predict what the conditions are going to be after the seed is planted, the best insurance against poor stands is to protect the seed as much as possible from invasion by the soil organisms.

Such protection, afforded by the application of chemicals to the surface of seeds, has long been recognized as a method of improving stands of vegetable crops. Seed treatments have not only made it safe for the market grower to plant seed early for most profitable returns, but have allowed the grower of processing crops to schedule his plantings over a long period to prevent harvest gluts.

Recommendations for seed treatments continue to change as newly developed pesticides or methods of application prove to be more effective, more economical, less toxic to the plant, or less hazardous to health than treatments in current use. The first recommended seed treatments consisted of dipping seed in solutions of salts of mercury or copper. Inorganic mercury compounds were replaced by less corrosive and less phytotoxic organic mercurials which were applied in

dust form. Copper solutions were replaced by copper dusts, first in the form of carbonates and later in the form of oxides which were more adhesive and less toxic to the seed. Zinc oxide was also used. Organic mercurials are used today primarily as seed disinfectants for small grains. Copper and zinc oxides are now used only to a limited extent on some vegetable seeds.

The decade beginning in 1940 was marked by the discovery and widespread adoption of organic chemical compounds as pesticides. Included among these newly developed pesticides were a number of fungicides and insecticides of unprecedented efficiency. During this period, slurry methods of application were developed to eliminate the health hazard created by floating particles of pesticides from dust applications. Slurry treatments also increase the adhesion of the pesticides, especially to smooth-coated seeds.

In 1950, as a result of several years of intensive research, the first effective fungicide-insecticide combination seed treatment was introduced by investigators at this Station.[1] That work revealed the necessity of simultaneously protecting the seed from decay and insect pests which hamper normal stands and thus introduced a new concept in the evolution of seed treatment methods and materials. The combination treatment of seeds is now being generally adopted throughout the United States as the most effective treatment for seeds of crops such as bean, corn, pea, pumpkin, squash, and others. Crops such as beet, carrot, spinach, and tomato have not been observed to respond to the combination treatment.

New fungicides are constantly being developed. This necessitates a continual testing of the new materials along with those presently accepted in order to determine those that are most effective and efficient under a wide range of conditions. Many materials are discarded after only one or two tests because they are decidedly inferior. Others may prove very effective for one crop, but are not necessarily any better than another which is suitable and effective for a variety of crops. Occasionally, a material may prove superior to the recommended fungicide in small experimental hand-planted tests, but will not be practical on seeds planted with a machine planter because of reduced rate of flow or for some other reason. Formulations are changed by the manufacturers and some materials are no longer available. For these reasons certain materials are eliminated from further testing.

The purpose of this bulletin is to present evidence, based on experi-

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[1]Howe, W. L., Schroeder, W. T., and Swenson, K. G. Seed treatment for control of seed-corn maggot and seed-decay organisms. *New York State Agr. Expt. Sta. Bul. No. 752. 1952.*

ments conducted during the past 11 years, on the performance of certain materials or combinations as protectants against seed decay or pre-emergence damping-off in seeds of bean, carrot, corn, cucurbit, crucifer, pea, pepper, spinach, and tomato. It is also intended to discuss, insofar as is possible, certain aspects of the treatment of seeds or the use of treated seed as it may affect the grower of processing crops. The materials are discussed by crop. Not all detailed data are given, only those that illustrate why certain materials are considered more effective.

Procedure

All fungicide materials in the experiments reported here were obtained from the manufacturer, either as experimental materials or proprietary formulations. They were used at dosages recommended by the manufacturer or at varied dosages and were applied either as dusts or slurries.

In the evaluation of seed treatment materials, the primary aim was to test the materials under a wide range of soil conditions, including soil types, soil reaction, moisture, temperature, and inoculum potentials. Many tests were conducted in greenhouse soil known to be heavily infested with seed-decay and damping-off organisms, sometimes at one temperature and other times at a series of soil temperatures.

Most frequently, the tests were carried out in the field at different planting dates to cover a range of soil moisture and temperature conditions. In some instances and with certain crops, such as cabbage and tomato, greenhouse soils from commercial plant growers were used. When it was desirable to know if a particularly good material was toxic to the plant in some manner or other, it was tested in sterilized sand or pasteurized soil.

All experiments were designed as randomized blocks. The number of replicates varied from four to six, depending upon the experiment, and the number of seeds planted in each replicate ranged from 40 in some greenhouse tests to 200 in the hand-planted field tests. In machine-planted experiments, particularly with peas, large quantities of seed were used. The stands in such tests were determined by calculating the number of seeds sown per given length of row, based upon the number of seeds per pound and the number of pounds planted per given row length, counting the number of plants emerged in a given length of row, and determining the percentage emergence.

All data were analyzed statistically, usually on the basis of the analysis of variance. Quite frequently, factorial experiments were carried out to measure effects, such as, dust versus slurry application, varieties, fungicide-insecticide combinations, preplanting storage treat-

ments, etc. In some tests, no significant differences were obtained among the various treatments and the nontreated controls, due in most instances to the absence of environmental conditions favorable for seed decay. In those cases, the differences in stand followed the same trend as in tests where they were highly significant.

Many materials were carried repeatedly in tests; others were discarded after one or two tests, usually because they were obviously inferior or were no longer being developed by the manufacturer. In crops where many experiments were conducted, the relative value of the more promising materials was determined, in part, by the percentage of tests in which the total emergence or stand of normal plants of any single treatment was numerically greater than that for any other treatment. This value followed very closely the significant differences obtained in experiments where seed decay was severe and thus represented a fair estimate of the value of any given compound.

Materials Used

The various chemical pesticides used in these experiments are listed below.

PESTICIDES USED IN SEED TREATMENT TESTS.

PESTICIDE	ACTIVE INGREDIENT[a]
Arasan	Thiram (50%)
Arasan SF	Thiram (75%)
Arasan SF–X	Thiram (75%)
Barbak C	N,N′-mercuridicarbanilonitrile
C and C No. 224	mercury zinc chromate
C and C No. 640	copper zinc chromate
Captan	N-(trichloromethylthio)-4-cyclohexene-1,2-dicarboximide
Ceresan M	N-(ethylmercuri)-p-toluenesulfonanilide
Chloranil	tetrachloro-p-benzoquinone
Chlordane	1,2,3,4,5,6,7,8,8-octachloro-4,7-methano-3a,4,7,7a-tetrahydroindane
C–O–C–S	basic copper chloride; basic copper sulfate
Corrosive sublimate	mercuric chloride
Dichlone	2,3-dichloro-1,4-naphthoquinone
Dieldrin	hexachloroepoxyoctahydro-endo, exo-dimethanonaphthalene
Dow 9B	zinc, 2,4,5-trichlorophenoxide
Ferbam	ferric dimethyldithiocarbamate
Fermate	Ferbam
GLF Bean Seed Treatment (GLF Combination Seed Treatment No. 1)	Thiram; lindane
I and D Seed Protectant	Thiram; lindane
I and D Seed Protectant (Delsan)	Thiram; dieldrin
Lindane	gamma-1,2,3,4,5,6-hexachlorocyclohexane
New Improved Ceresan	ethyl mercury phosphate
Orthocide 75 Seed Protectant	Captan (75%)
Ortho Seed Guard	Captan; lindane
Panogen	cyano(methylmercuri)guanidine

Parzate	Zineb
Phygon	Dichlone (50%)
Phygon XL	Dichlone (50%)
Semesan	2-chloro-4-(hydroxymercuri)phenol
Semesan Jr	ethyl mercury phosphate
Spergon	Chloranil
Tag	phenylmercury acetate
Thiosan	Thiram (50%)
Thiram	bis(dimethylthiocarbamoyl)disulfide
Tri-Basic	basic copper sulfate
Vancide 51	sodium dimethyldithiocarbamate; sodium derivative of 2-mercaptobenzothiazole
Vancide 51-ZW	Ziram; zinc derivative of 2-mercaptobenzothiazole
Yellow Cuprocide	cuprous oxide
Zerlate	Ziram
Zineb	zinc ethylenebis(dithiocarbamate)
Ziram	zinc dimethyldithiocarbamate

[a]Where pesticide contains more than one active ingredient, each material is separated by a semicolon.

Results

Bean Seed Treatment

Lima Beans

In this bulletin, only lima bean seed treatment tests conducted from 1952 through 1954 will be presented. Lima bean seed treatments conducted prior to 1952 were discussed in the publication cited above. That publication contains the original investigations in the development of the combination fungicide-insecticide treatments for the protection of lima bean seed from seed-decay organisms and the seed-corn maggot. In those investigations effective protection of lima bean seed was obtained with a combination fungicide-insecticide treatment. Treatment of lima bean seed with fungicide or insecticide alone was unsatisfactory.

On the basis of previous studies, the treatment recommended for lima bean seed consisted of 1.3 ounces of Arasan SF plus 1 ounce of 25 per cent wettable powder formulation of aldrin, dieldrin, or lindane, or 50 per cent wettable powder chlordane, applied in slurry form at the rate of ½ pint slurry to a bushel of seed.

The fungicides Spergon and Phygon were found to be inferior because they had a tendency to harden the seed coat of beans under some conditions. This factor interferred with normal emergence so those materials were discarded. Captan was not available at that time.

The slurry was prepared by suspending the pesticides in a 4 per cent Methocel[2] solution or by dispersing the pesticides and Methocel powder in the required volume of water.

This combination fungicide-insecticide treatment proved so successful that this method of protection of lima bean seed was generally

[2]Methocel (15 c.p.s.), Dow Chemical Company, Midland, Mich.

adopted; in fact, it has been successfully applied to other maggot-susceptible seed, such as that of corn, pumpkin, and others.

Occasionally, despite seed treatment, poor stands of lima beans have occurred. These inconsistent results have indicated that the combination treatments may not be effective under all conditions or that factors other than the pesticides are operative. For this reason, there is still need for testing the recommended treatments under a wide range of environal conditions to obtain information on the limitations of the present treatments. Also, there is a need for testing new materials for the purpose of developing a more effective treatment under diverse conditions.

During the period 1952–54, lima bean seed treatment tests were conducted to obtain additional information on the influence of duration and temperature of storage of treated seeds on the pesticidal value of the treatments and on possible deleterious effects of storage on the viability and vigor of treated seeds. Also, a number of commercial fungicide-insecticide preparations and laboratory preparations of recently introduced pesticides were tested along with accepted treatments to find those that would be the most effective under a wide range of planting conditions.

Influence of duration of storage on pesticidal value of treatments and viability and vigor of seed, 1953 tests

In 1952 and 1953, lima bean seed which had been treated and stored for various lengths of time at different temperatures was hand-planted in plots at Geneva. The results of the tests of each of these years from the stored seed were essentially the same. Since the 1953 tests provide information on one additional year of storage of the treated seed, as well as the results from a number of commercial pesticide preparations, only the 1953 results will be discussed.

All seed in the 1953 lima bean seed treatment test originated from a single lot of Clark's bush lima bean harvested in 1949. In October 1950, one-half of the seed was placed in storage maintained at 40° to 50°F and the remainder of the seed was placed in storage held at 70° to 80°F. A portion of the seed stored at each temperature was treated in October 1950, and the remaining untreated seed was saved for subsequent storage tests for the purpose of evaluating freshly applied treatments with treatments applied long in advance of planting.

In May 1951, a portion of the untreated stored seed was treated with similar pesticides as in October 1950.[3] In June 1951, all seed was placed

[3]The results of the two storage temperatures for seed treated and stored for 8 months and untreated seed stored under the same conditions but treated just before planting are outlined in Bulletin No. 752 of this Station, previously cited.

in storage maintained at 40° to 50°F. In June 1953, untreated stored seed was treated with laboratory and commercial preparations of fungicide-insecticide combinations. Treatments and storage conditions of seed are listed in Table 1. Plantings of seed treated in 1950 and 1951 and stored until 1953, and seed from the same seed lots treated just prior to planting, were made in 1953. All treatments were randomized in replicated plantings at each of two locations.

Seed decay and maggot injury were not severe in these tests, and as a result, excellent stands were obtained from most treatments. Sufficient seed decay and maggot injury did occur to provide for the evaluation of the effectiveness of freshly applied treatments with treatments applied long in advance of planting.

On the basis of total emergence, duration of storage of seed in a treated condition had no adverse effects on the viability and vigor of the seed. In the planting of June 6, 1953, total emergence from seed treated and stored since October 1950 and from seed treated and stored since June 1951 did not differ from that of seed treated just prior to planting in 1953, or that of seed not treated (Table 1). Similarly, in the planting of June 18, 1953, total emergence from treatments applied at various intervals before planting did not differ significantly. The total emergence from untreated seed in the latter planting was significantly less than that from the treated seed.

On the basis of normal plants (free of injury from seed-decay organisms or the seed-corn maggot), the treatments retained their pesticidal effectiveness on the seed even after a period of 32 months of storage. In the early planting, the benefits of treatment with a fungicide could not be demonstrated since seed decay was not an important factor in this test (Table 1). On the other hand, in this test, injury from seed-corn maggot was sufficiently severe in treatments lacking an insecticide that the benefits of maggot control were clearly evident. Since the percentage of normal plants from all treatments containing an insecticide were comparable, regardless of the date of treatment of the seed, duration of storage of treated seed had no apparent effect on the pesticidal value of the insecticides.

In the late planting, seed-corn maggot injury was of minor importance so that no evaluation of the effectiveness of the insecticide treatments on the different lots of seed was possible. Seed decay, on the other hand, was sufficiently severe to provide evidence that the duration of storage of treated seed had no influence on the effectiveness of the fungicide Arasan SF (Table 1).

Factorial analyses of the combined results of the 1953 plantings of seed treated in October 1950 and of seed treated in May 1951 indicated

TABLE 1.—TOTAL EMERGENCE AND NORMAL PLANTS FROM CLARK'S BUSH LIMA BEAN SEED STORED FOR DIFFERENT LENGTHS OF TIME AT TWO TEMPERATURES AFTER TREATMENT WITH INSECTICIDE-FUNGICIDE PREPARATIONS.

PESTICIDES[a]	STORAGE TEMPERATURE, °F	EMERGENCE, PER CENT — Planted June 5, 1953		EMERGENCE, PER CENT — Planted June 18, 1953	
		Total	Normal	Total	Normal
Treated Storage Period, 32 Months					
Arasan SF + lindane	40°–50°	89	85	88	87
Arasan SF + lindane	70°–80°[c]	90	85	89	88
Arasan SF + dieldrin	40°–50°	93	89	90	89
Arasan SF + dieldrin	70°–80°	92	88	82	79
Arasan SF + chlordane	40°–50°	92	84	92	89
Arasan SF + chlordane	70°–80°	85	76	84	82
None	40°–50°	87	60	77	75
None	70°–80°	82	59	70	68
Arasan SF	40°–50°	84	59	86	84
Arasan SF	70°–80°	88	71	84	83
Treated Storage Period, 24 Months					
Arasan SF + lindane	40°–50°	91	85	91	88
Arasan SF + lindane	70°–80°	86	76	86	83
Arasan SF + dieldrin	40°–50°	91	87	87	85
Arasan SF + dieldrin	70°–80°	90	88	85	85
Arasan SF + chlordane	40°–50°	88	79	91	89
Arasan SF + chlordane	70°–80°	86	81	87	86
None	40°–50°	88	67	74	72
None	70°–80°	86	65	66	63
Arasan SF	40°–50°	88	73	87	84
Arasan SF	70°–80°	84	63	86	84
Treated Storage Period, None[b]					
GLF Bean Seed Treatment	40°–50°	90	86	86	86
OLF Bean Seed Treatment	70°–80°	89	85	89	88
Grtho Seed Guard[d]	40°–50°	90	80	91	89
Ortho Seed Guard[d]	70°–80°	90	83	83	79
DuPont I and D (dieldrin)[d]	40°–50°	93	89	91	90
DuPont I and D (dieldrin)[d]	70°–80°	91	86	89	88
DuPont I and D (lindane)[d]	40°–50°	91	86	89	88
DuPont I and D (lindane)[d]	70°–80°	88	81	85	82
Arasan SF-X + dieldrin	40°–50°	92	87	87	86
Arasan SF-X + dieldrin	70°–80°	90	86	85	82
Arasan SF-X + lindane	40°–50°	89	83	89	89
Arasan SF-X + lindane	70°–80°	91	85	88	86
Orthocide 75 + lindane	40°–50°	92	88	92	90
Orthocide 75 + lindane	70°–80°	88	84	89	88
Least difference required for significance	(19:1)	5	7	6	7
	(99:1)	6	10	8	10

[a]Arasan SF, Arasan SF-X, and Orthocide 75 applied to seed at dosage of 1.3 ounces per bushel; lindane 25, dieldrin 25, and chlordane 50 at 1 ounce per bushel. All materials except propietary formulations applied in a 4 per cent Methocel slurry at rate of ½ pint per bushel.

[b]Treatments with no treated storage period were applied to seed maintained in the untreated condition with the treated seed at the storage temperatures indicated.

[c]Seed maintained in storage at 70°–80°F for 8 months, then maintained in storage at 40°–50°F for duration of experiments.

[d]Proprietary formulations, applied according to manufacturers' directions.

no differences in total emergence among the fungicide-insecticide combinations. The total emergence from treated seed was greater than that from the untreated seed (Table 2). The percentage of normal plants from the combination fungicide-insecticide treatments was significantly greater than that from treatments with fungicide alone. The normal plants from untreated seed were significantly fewer than those from any of the treated seed.

Total emergence and normal plants from seed stored for 32 months in a treated condition and of seed stored for 24 months in a treated condition were identical for the two lots of seed (Table 2). Since the total emergence and normal plants from freshly applied treatments (Table 1) did not differ from treatments applied long in advance of planting, duration of storage of seed in a treated condition had no influence on the effectiveness of the treatments or the vigor of the seed.

The commercial fungicide-insecticide preparations, as GLF Bean Seed Treatment, Ortho Seed Guard, and DuPont I and D containing either lindane or dieldrin, were as effective as laboratory preparations

TABLE 2.—SUMMARY OF FACTORIAL ANALYSES OF THE EFFECTS OF TREATMENTS, STORAGE DURATION, AND TEMPERATURE OF TREATED SEEDS ON TOTAL EMERGENCE AND NORMAL PLANTS OF CLARK'S BUSH LIMA BEAN PLANTED AT TWO LOCATIONS, 1953.

	TOTAL EMERGENCE, PER CENT	NORMAL PLANTS, PER CENT
Seed Treatments		
Arasan SF + lindane	89	85
Arasan SF + dieldrin	89	86
Arasan SF + chlordane	88	83
Arasan SF	86	75
None	79	66
Least difference required for significance		
(19:1)	2	3
(99:1)	3	4
Duration of Storage[a]		
Treated, stored for 32 months	86	79
Treated, stored for 24 months	86	79
Storage Temperature[b]		
Stored at 40°–50°F	88**	80*
Stored at 70°–80°F	84	78
Interactions		
Seed treatment × storage temperature	NS	NS
Seed treatment × duration of storage	NS	NS
Storage temperature × duration of storage	NS	NS
Seed treatment × storage temperature × duration of storage	NS	NS

*Significant at odds of 19:1.
**Significant at odds of 99:1.
NS = not significant.
[a]Portion of seed treated and stored in October 1950; another portion stored in October 1950 but treated in May 1951. Seed maintained in storage, planted June 1953. No significant differences.
[b]Portion of seed stored from October 1950 to June 1951 at 40°–50°F; another portion for the same period at 70°–80°F. All seed stored June 1951 to June 1953 at 40°–50°F.

of fungicide-insecticide combinations. Orthocide 75 and Arasan SF-X were equally effective (Table 1).

No data on the influence of storage on the effectiveness of commercial preparations are available. Some of these commercial preparations are similar to the laboratory preparations which were used in the storage tests. It is reasonable to assume that the commercial preparations will perform in the same manner as the laboratory preparations did in the storage tests.

On the basis of these tests on seed stored for extended periods in a treated condition and seed freshly treated before planting, duration of storage has no deleterious effects on the vigor of treated seed nor any apparent influence on the pesticidal value of the treatments on the seed under average growing conditions. Whether the pesticides deteriorated under the above storage conditions or did not deteriorate beyond the protective threshold was not determined.

Influence of storage temperature on pesticidal value of treatments and viability and vigor of seed

The temperature at which lima bean seed is stored was observed to influence results of seed treatment tests conducted in 1953 and 1954. Since the tests conducted during these years differed in respect to treatments, variety of lima bean, duration and temperature of storage, and environmental conditions at time of planting, the results of the tests during each year will be considered separately.

1953 Tests

Seed lots of Clark's bush lima bean were stored in a treated and untreated condition at temperatures of 40° to 50°F and 70° to 80°F. After about 8 months of storage, the seed lots maintained at the higher temperatures were transferred to storage maintained at 40° to 50°F. All seed then was maintained at the lower temperature until planting time. Details of treatments and storage temperatures are listed in Table 1.

On the basis of the factorial analyses of the combined results of the two 1953 plantings, total emergence was significantly greater from seed stored at 40° to 50°F throughout the course of the tests than from seed stored at 70° to 80°F for the first 8 months following treatment (Table 2). The reduction in total emergence from seed stored at 70° to 80°F was not due to any adverse effect of the treatments, but rather was due to loss in vigor of the seed itself since a comparable reduction in emergence occurred from untreated seed stored at the higher temperature. None of the interactions between storage temperature, treatments,

and duration of storage was significant (Table 2). Storage temperature, therefore, had no specific influence on any treatment. The difference between total emergence and normal plants averaged about 7 per cent for each category of seed. This indicates that the higher storage temperature had no adverse influence on the pesticidal properties of the treatments.

1954 Tests

The influence of a brief storage period at high temperature on lima bean seed treated by slurry and dust methods was investigated in two tests conducted in 1954. Seed of Fordhook 242 lima bean was treated April 19. A portion of the treated seed and of untreated seed was held at room temperature (68° to 75°F) until planting time. Another portion of the same seed was placed for 9 days immediately after treatment in a cabinet maintained at 88° to 90°F. After this storage period at high temperature, all seed was maintained at room temperature until planted.

In the first test, seed was hand-planted on April 28 in sandy soil at Oaks Corners, N. Y. Cold soil conditions so delayed germination that the seedlings began to emerge about 3 weeks after planting. The conditions that prevailed favored seed decay, which was further enhanced by injury to the seed by feeding activities of soil insects. Under these severe conditions, response to seed treatments was very poor. The average total emergence from treatments containing a fungicide was 28 per cent, while that from treatments lacking a fungicide was 9 per cent (Table 3).

The total emergence from seed held at 88° to 90°F for a period of 9 days after treatment was consistently less than that from seed maintained at room temperature. This reduction in emergence was not due to any adverse effect of the treatments at the high temperature since the untreated seed was also adversely affected by the higher temperature. On the basis of normal plants, the seed held at room temperature averaged 24 per cent; whereas, the seed maintained at the high temperature averaged only 12 per cent. This reduction in normal plants was not due to any adverse effects of the high temperature on the pesticidal value of the treatments, since interactions between treatments and storage temperatures were not significant. Apparently, exposure of the seed to high temperature weakened the seed.

Differences in the average total emergence from treatments containing Arasan and Orthocide 75 were not statistically significant. However, in regard to individual treatments, slurry treatments containing Arasan and lindane were superior to any other treatments. The significant interactions of fungicides with insecticides and of fungicides

Table 3.—Response of Treated and Untreated Fordhook 242 Lima Bean Seed to a Relatively Short (9 Days) Storage Period at a High Temperature as Measured by Total Emergence at Two Locations, One Ideal and One Unfavorable for the Development of Seed Decay and Maggot Injury, 1954.

Materials[a]	Total emergence, per cent			
	Oaks Corners		Seneca Castle	
	68°–75°F	88°–90°F[b]	68°–75°F	88°–90°F[b]
Arasan + lindane dust..........	30	20	85	84
Arasan + lindane slurry.........	48	29	78	84
Orthocide + lindane dust.......	35	20	85	81
Orthocide + lindane slurry......	33	27	83	80
Arasan + dieldrin dust.........	30	17	85	85
Arasan + dieldrin slurry.......	40	21	79	82
Orthocide + dieldrin dust......	32	15	84	84
Orthocide + dieldrin slurry.....	33	20	85	81
Dieldrin dust..................	12	5	63	58
Dieldrin slurry................	11	7	55	50
Lindane dust..................	15	5	71	66
Lindane slurry................	11	6	58	66
Arasan dust..................	30	18	88	84
Arasan slurry.................	30	24	84	80
Orthocide dust................	34	23	83	83
Orthocide slurry..............	36	20	83	81
No treatment.................	7	6	81	78
No treatment (Methocel slurry only)......................	15	5	74	65
Ortho Seed Guard slurry........	36	20	86	78
DuPont I and D slurry.........	50	22	81	80
GLF Combination Treatment slurry.....................	39	30	83	83
Least difference required for significance (19:1)................	13		8	
(99:1)................	17		10	

[a]Dosage of pesticides in ounces per bushel: Arasan (50%), 2.0; Orthocide (75% seed treater), 1.3; lindane (75%), 0.33; dieldrin (50%), 0.50. Slurry treatments made up by adding materials to 2 per cent Methocel at the rate of ½ pint per bushel. The proprietary formulations Ortho Seed Guard, DuPont I and D, and GLF Combination Treatment were applied according to manufacturer's directions.

[b]High temperature exposure. Immediately after treatment, part of the seed was stored for 9 days at temperature of 88° to 90°F, then kept at room temperatures of 68° to 75°F until planted.

with method of application resulted from the superior performance of the Arasan-lindane slurry treatment. Also, dust treatments with Arasan were less effective than the slurry treatments; whereas, with Orthocide 75 no such differences existed.

The second planting was made in dry soil at Seneca Castle, N. Y., on July 7. Seedlings did not emerge until 3 weeks after planting. Injury

from insect activity was entirely absent, and seed decay was of minor importance. The total emergence from seed exposed for a short period to a high temperature did not differ from that of seed which had been held at room temperature until planting. The low percentage emergence of seed stored briefly at the high temperature in the early planting, therefore, was not due to the death of the seed but to a weakening of the seed stored at the high temperature. The high total emergence in the latter planting, regardless of temperature exposure of the seed, in comparison to a reduced emergence from similarly treated seed in the early planting indicated that any factor which reduces the vigor of the seed, even to a slight extent, may become manifest in a marked reduction in emergence under conditions conducive to seed decay.

Differences in total emergence from treatments containing Arasan or Orthocide 75 alone, or in combination with either dieldrin or lindane, were not statistically significant. The total emergence from untreated seed was not significantly different from that of seed treated with a fungicide alone, or in combination with an insecticide. In the absence of insect activity, however, emergence from seed treated with insecticide alone was 20 to 30 per cent lower than when a fungicide was added. Dieldrin slurry alone resulted in the greatest reduction in emergence.

Total emergence from seed treated by the slurry method was consistently less than that from seed treated with the same pesticides applied in the form of a dust. Since the total emergence from seed treated with Methocel slurry alone was significantly lower than that from untreated seed, the reduction in emergence was due to the effect of Methocel slurry treatment on the seed and not to any interaction between Methocel and the pesticides in this test.

Dry Beans

Seed treatment tests to compare effectiveness of materials such as Arasan or Orthocide 75 alone, or in combination with lindane applied either as a dust or slurry to seed of California Red Kidney bean and to Perry Marrow bean were conducted in 1953. Seeds of the two varieties were treated on May 11 and planted by hand on May 22. Both varieties were randomized within the same blocks.

Seed decay was not a factor with California Red Kidney seed. Total emergence from untreated seed in some instances was higher than that from seed treated with a fungicide alone (Table 4). Insect injury, on the other hand, was of major importance. Total emergence and normal plants from seed treated with an insecticide averaged from

20 to 30 per cent higher than that from seed not treated with an insecticide. In this test, treatment with insecticide alone resulted in an excellent stand; whereas, in most tests, treatments with insecticides have resulted in a reduction in emergence.

Treatments with the commercial preparations gave excellent results with the exception of Ortho Seed Guard. In other tests, Ortho Seed Guard was one of the most effective treatments. The average total emergence and normal plants of all treatments containing Arasan were lower than those of all treatments containing Orthocide 75. The reason for the superiority of Orthocide 75 in this test was the poor performance of the Arasan dust treatments. With Orthocide 75, dust and slurry treatments were equally effective.

The results of this test clearly demonstrate the value of incorporating an insecticide in the seed protectant preparation.

Both seed decay and insect injury were important factors in the test with Perry Marrow bean. As a result, treatments with a fungicide-insecticide combination proved to be more effective than treatments with either type of pesticide alone (Table 4). Total emergence and

Table 4.—Total Emergence and Normal Plants from California Red Kidney and Perry Marrow Bean Seed Treated with Fungicide or Insecticide Alone or in Combination Applied Either as a Dust or Slurry, 1953.

Treatments[a]	Emergence, per cent			
	California Red Kidney		Perry Marrow	
	Total	Normal	Total	Normal
Arasan dust	52	29	52	27
Arasan + lindane dust	76	62	57	37
Arasan SF–X slurry	56	34	53	29
Arasan SF–X + lindane slurry	83	71	72	62
Orthocide 75 dust	55	31	53	27
Orthocide 75 + lindane dust	83	76	80	68
Orthocide 75 slurry	60	37	58	32
Orthocide 75 + lindane slurry	84	78	81	72
Lindane dust	82	73	52	43
Lindane slurry	85	77	45	37
Methocel slurry	64	41	47	26
DuPont I and D (lindane)	85	79	73	62
DuPont I and D (dieldrin)	86	83	82	77
Ortho Seed Guard	70	47	80	72
GLF Bean Seed Treatment	87	84	85	83
No treatment	64	41	45	23
Least difference required for significance				
(19:1)	9	9	9	9
(99:1)	12	12	12	12

[a]Dosage of pesticides in ounces per bushel: Arasan dust (50%), 2.0; Arasan SF-X, 1.3; Orthocide 75, 1.3; lindane (75%), 0.33. In laboratory slurry preparations pesticides were suspended in 2 per cent Methocel; slurry applied to seed at volume of ⅓ pint per bushel. DuPont I and D with either lindane or dieldrin, Ortho Seed Guard, and GLF Combination Treatment applied according to manufacturer's directions.

normal plants from all treatments containing Orthocide 75 were greater than those from the treatments containing Arasan. As in the test with California Red Kidney bean, the poor performance of the Arasan dust treatments resulted in Orthocide 75 gaining an over-all advantage over Arasan. The commercial preparations GLF Bean Seed Treatment, Ortho Seed Guard, and DuPont I and D gave excellent results.

Snap Beans

A single seed treatment test with Tendergreen snap bean was conducted in 1954. This test was designed to compare the effectiveness of treatments with Arasan and Orthocide 75 alone and in combination with either dieldrin or lindane. Treatments were applied in dust and slurry form. DuPont I and D, GLF Bean Seed Treatment, and Ortho Seed Guard were included in the test.

Seed decay and insect injury were negligible factors in this test. Under these conditions, emergence from each of the treatments averaged near 90 per cent. The total emergence from all treatments containing Arasan averaged slightly greater than those from treatments containing Orthocide 75. The difference between these fungicide treatments was too slight to be of any practical significance. The number of plants from treatments containing an insecticide averaged about 2 per cent less than that from treatments lacking an insecticide. Differences between dust and slurry methods of application were not significant.

Results of bean seed treatment tests may vary considerably depending upon environmental conditions, variety and vigor of seed, and treatments applied to the seed. Of the various factors influencing the results of bean seed treatment tests, environmental conditions are the most important, but the interrelationship of all factors must be considered in interpreting the results.

The lima bean tests conducted in 1953 and 1954 provide examples of the variability that may be encountered under different environmental conditions. In 1953, under average conditions, treatments with the fungicide-insecticide combination resulted in excellent stands. Under these conditions loss in vigor of the seed as a result of a prolonged storage temperature of 70° to 80°F resulted in a slight reduction in total emergence. In the early planting of 1954, under conditions adverse to germination but ideal for seed decay, the stand was very poor even with the best treatments. Normally, commercial plantings would never go in at that early date. Loss in vigor of the seed as the result of a 9-day exposure of the seed to a temperature of 88° to 90°F was reflected in marked reduction in emergence. In the late planting of 1954, where insect damage was absent and seed decay was of minor

importance, the fungicide-insecticide combinations or fungicides alone resulted in stands only slightly better than those from untreated seed. In contrast to the results of the early planting of 1954, high temperature exposure of the seed had very little effect on total emergence. Treatment of seed with an insecticide alone, however, caused a 20 to 30 per cent reduction in stand, which confirms the previously reported need of combining a fungicide with an insecticide. These results show that under certain conditions seed treatments may not be effective, or they may be very effective, or they may not be necessary, or under extreme conditions, some treatments may even be detrimental.

The variation in results obtained under different conditions has at times created doubt in the grower's mind as to the value of seed treatments. However, if the limitations of bean seed treatments under a wide range of conditions are established, the variation in results from seed treatments can be explained. As more information on the various aspects of lima bean seed treatment is gained, current materials or recommended dosages of these materials, methods of application of treatments, and methods and time of planting may be changed to overcome some of the limitations of the current treatments.

Under average conditions, combination fungicide-insecticide treatments have performed so well that bean growers in New York State have adopted this method of seed treatment as a necessary practice to obtain satisfactory stands. Commercial preparations containing Arasan SF (thiram) in combination with dieldrin or lindane or preparations containing Orthocide 75 (captan) plus an insecticide are in general use.

Seed of dry bean and snap bean varieties may not incur as much injury from seed-decay organisms and seed-corn maggot as do the large-seeded types of lima bean, but the increased stands of vigorous plants of dry and snap beans as the result of seed treatment with fungicide-insecticide combinations have convinced growers of the importance of this method of seed protection.

Beet Seed Treatment

Poor stands of beets are frequently the result of seed decay and pre-emergence damping-off of seedlings. Treatment of beet seed with a fungicide protects the seed from decay and may also provide some protection against pre-emergence damping-off.

Poor stands of beets may also be the result of post-emergence damping-off of seedlings. This is usually characterized by a water-soaked, collapsed condition of stem of the seedling at the soil line, followed by wilting and death of the plant. Seed treatments are of little or no value in controlling post-emergence damping-off. The results of the

beet seed treatment tests, therefore, indicate the value of fungicides in protecting seed from decay and seedlings from pre-emergence damping-off.

During the period from 1946 through 1953, 14 different beet seed treatment tests were conducted, some in the greenhouse and others in the field. Because the materials in each test were not always the same and because of the large number of materials tested, the results of these tests are summarized in table 5. In this table, the effectiveness of a

TABLE 5.—RELATIVE VALUE OF BEET SEED TREATMENTS, 1946–53.

MATERIAL	DOSAGE, PER CENT BY WEIGHT OF SEED	NUMBER OF TESTS	RELATIVE VALUE[a]
Phygon	0.5	5	82
Phygon XL	1.0	5	75
Phygon	1.0	9	70
Orthocide 75	1.0	5	68
Vancide 51	3.0	5	67
Yellow Cuprocide	1.0	12	61
Dow 9B	1.0	6	61
Arasan	1.0	9	58
Arasan SF	1.0	5	58
Orthocide 75	0.5	5	58
Panogen	1.0	5	58
Yellow Cuprocide	1.5	2	57
Arasan	0.5	5	47
Semesan	1.0	6	45
Zerlate	1.0	6	27
Yellow Cuprocide	0.75	2	21
Arasan SF–X	0.75	5	20
No treatment	—	14	11

[a]Relative value = Percentage of tests in which total emergence from a treatment was numerically greater than that from any other treatment.

particular fungicide on the basis of total emergence is indicated by the relative value calculated for each fungicide. This relative value represents the percentage of tests in which the total emergence of seedlings from a particular treatment was numerically greater than that from any one of the other treatments. A high relative value indicates that seed treatment with that fungicide resulted in high total emergence in the majority of the tests.

On the basis of relative value, Phygon consistently proved to be the most effective. Orthocide 75 at 1.0 per cent by weight of the seed and Vancide 51 followed next in order of effectiveness. Yellow Cuprocide at 1.0 and 1.5 per cent, Dow 9B, Arasan, and Arasan SF at 1.0 per cent, Orthocide 75 at 0.5 per cent, and Panogen formed a group intermediate in effectiveness. Arasan at 0.5 per cent, Arasan SF-X and Yellow Cuprocide at 0.75 per cent, Semesan, and Zerlate formed a group with low relative values.

These relative values indicated that Phygon was the most effective beet seed protectant of the materials tested. Arasan, Orthocide 75, Yellow Cuprocide, and Panogen at 1.0 per cent and Vancide 51 at 3.0 per cent were also effective treatments. Arasan and Orthocide 75 at a dosage of 0.5 per cent by weight of seed did not provide sufficient protection. Arasan SF-X should not be used as a dust treatment for beet seed.

Phygon and Panogen appeared to have some value in protecting seedlings from post-emergence damping-off in greenhouse tests. However, in field tests, the control of post-emergence damping-off by these materials has not been consistent.

There is a definite need for a treatment to control post-emergence damping-off. Post-emergence damping-off can lead to losses because of reduction in stand, losses in value of crop because of development of over-sized beets in reduced stands, and rejection of crop because of beets affected with a dry rot initiated by damping-off organisms.

Carrot Seed Treatment

Carrot is somewhat erratic in its response to seed protectants. Post-emergence damping-off is probably as important as seed decay or pre-emergence damping-off. There are enough instances, however, where seed decay may be quite a factor in poor stands.

In 1948, a number of seed protectants were tested for their effectiveness against seed decay. The tests were run in greenhouse benches containing both muck and upland soil since carrots are grown in both. On the basis of these experiments, the outstanding fungicides of those tested were Phygon, Arasan, and Ceresan M (Table 6). On muck soil, Phygon at 0.5 per cent by weight of seed topped the list, followed in order by Ceresan M at 0.5 per cent, Phygon at 1.0 per cent, and Arasan at 1.0 per cent. None of the above materials was significantly better than the other. On upland soil, the above fungicides again topped the list in the following order: Arasan at 1.0 per cent, Ceresan M at 0.5 per cent, and Phygon at 0.5 per cent. All other materials were inferior, especially Spergon.

Crucifer Seed Treatment

Cabbage, cauliflower, and broccoli seeds are planted either in the greenhouse and the seedlings pricked into flats for early crops, or they are seeded directly into field plant beds from where the plants are removed for late field plantings. In either instance, the best criterion of a seed-protecting fungicide is the percentage of healthy seedlings suitable for pricking. As with tomato, the seeds of the cabbage family

TABLE 6.—TOTAL EMERGENCE OF RED CORED CHANTENAY SEED TREATED WITH FUNGICIDE AND PLANTED IN MUCK AND UPLAND SOIL, 1948.

MATERIAL	DOSAGE, PER CENT BY WEIGHT OF SEED	TOTAL EMERGENCE, PER CENT			
		Muck soil 1	Muck soil 2	Muck soil 3	Upland soil 1
None	—	65	55	48	38
Arasan	0.5	66	57	56	50
Arasan	1.0	64	65	62	57
Phygon	0.5	63	69	64	53
Phygon	1.0	70	66	59	52
Spergon	0.5	66	54	45	34
Spergon	1.0	69	63	45	31
Yellow Cuprocide	0.5	61	56	46	36
Yellow Cuprocide	1.0	61	58	50	38
C & C No. 640	0.5	62	58	48	35
C & C No. 224	0.5	64	66	52	38
Ceresan "M"	0.5	63	67	63	55
Least difference required for significance					
(19:1)		NS	8	6	10
(99:1)		NS	10	8	14

should be hot water-treated and dried before applying the protectant.

In 1947, six materials were tested at different dosages in two separate experiments on cabbage in commercial plant-growing soil. Marion Market seed with a laboratory germination of 90 per cent was used.

Of the materials tested, Arasan dust was outstanding, either at a dosage of 0.5 per cent or 1.0 per cent by weight of seed (Table 7). Parzate at 0.5 per cent by weight was the next best material. All other materials in these two tests were inferior. In three other tests with

TABLE 7.—TOTAL EMERGENCE AND NUMBER OF HEALTHY SEEDLINGS FROM MARION MARKET CABBAGE SEED TREATED WITH VARYING PROTECTANTS AND PLANTED IN COMMERCIAL PLANT-GROWING SOIL, 1947.

MATERIAL	DOSAGE, PER CENT BY WEIGHT OF SEED	EMERGENCE, PER CENT[a]	
		Total	Healthy
HWT[b]	—	40	11
Check	—	64	17
HWT + Semesan	0.5	70	35
HWT + Semesan	1.0	72	37
HWT + Arasan	0.5	75	55
HWT + Arasan	1.0	80	66
HWT + Phygon	0.5	71	38
HWT + Phygon	1.0	76	40
HWT + Zerlate	0.5	72	35
HWT + Zerlate	1.0	72	40
HWT + Dow 9B	0.5	22	5
HWT + Parzate	0.5	75	49
Least difference required for significance (19:1)		6	6

[a]Average of two separate experiments.
[b]Hot water-treated 25 minutes at 122°F (50°C).

different soil, Arasan at 1.0 per cent was superior, followed by Zerlate at 1.0 per cent, and Parzate at 0.5 per cent. Captan was not available at the time these tests were conducted.

Cucurbit Seed Treatment

The cucurbits, squash, pumpkin, melon, and cucumber, are frequently treated with a mercuric chloride soak, especially if the angular leaf spot and anthracnose organisms are suspected as contaminants. That treatment necessitates a thorough rinsing to remove the mercuric chloride. Seed so treated is not protected against seed-decay organisms in the soil. Seed protectants, therefore, are necessary for cucurbit seed.

In 1948, a number of experiments were conducted to evaluate various seed protectants for cucurbits. They were applied to seeds of squash, pumpkin, and cucumber previously treated with mercuric chloride soak. They were also applied to seeds that received no other treatment. In addition, some seeds were first treated with water at 122°F (50°C) for 25 minutes and then with protectants after the seed had dried.

Results with various cucurbits, together with the treatments and dosages, are outlined in Table 8.

An interesting situation occurred among most of the treatments in relation to the mercuric chloride treatment of some of the cucurbits.

Table 8.—Response of Three Species of Cucurbits to Protectant Fungicides Applied After a Mercuric Chloride Disinfectant Soak, 1948.

Treatment	Dosage, per cent by weight of seed	Emergence, per cent[a]		
		Cucumber	Pumpkin	Squash
None	——	14	54	14
MC[b]	——	34	50	74
MC + Spergon	0.250	—	84	92
MC + Yellow Cuprocide	0.250	50	88	87
MC + Arasan	0.125	69	88	96
MC + Arasan	0.250	78	86	98
MC + Phygon	0.125	—	86	96
HWT[c]	——	—	66	15
HWT + Arasan	0.125	—	91	96
HWT + Phygon	0.125	—	91	96
MC + Spergon	0.500	38	—	—
MC + Arasan	0.500	78	—	—
MC + Phygon	.2500	39	—	—
Arasan	0.250	82	—	—
Phygon	0.250	85	—	—
Least difference required for significance (19:1)		2	9	7
(99:1)		3	12	9

[a]Varieties: Cucumber, National Pickling; squash, Blue Hubbard; pumpkin, Connecticut Field.
[b]Mercuric chloride soak—1 ounce mercuric chloride in 7½ gallons of water, soaked for 5 minutes, washed thoroughly, and dried.
[c]Hot water treatment, 122°F (50°C) for 25 min.

When Spergon, Phygon, and Yellow Cuprocide were applied as protectants at dosages of 0.125 and 0.250 per cent by weight of seed to cucumber seed previously treated with mercuric chloride, the plants developing from the seed were severely injured. Cotyledons were distorted and the plants were stunted. Arasan at either of the above dosages, or at 0.5 per cent, had much less adverse effect on the emerging plants. In fact, the plants were barely distinguishable from normal plants. Arasan and Phygon, the only materials tested when applied to seed not previously treated with mercuric chloride, produced the best stands. The adverse effects of the combination treatment of mercuric chloride soak and protectant were not nearly as marked on pumpkin and squash. In the latter, some retardation in emergence and slight distortion occurred, but the plants recovered shortly. The hot water treatment had no adverse effects on either squash or pumpkin.

It appears from these results that Arasan was the best protectant to use if the seed was previously treated with mercuric chloride, especially cucumber seed. Otherwise, Phygon was just as effective.

With the advent of the combination protectant of an insecticide with a fungicide for the control of seed decay, seed-corn maggot, and wireworm on beans, some success has been obtained on cucurbits with such treatments. In 1950, extensive tests were conducted with a number of such combinations on squash, but prevailing conditions were not conducive to the development of any such pests so that no significant results were obtained other than to indicate the treatments were not harmful. In actual practice, the combination treatments are used quite extensively in some areas.

Pea Seed Treatment

The pea seed treatment tests are separated into two main groups. The first group consists of tests conducted from 1946 through 1948 in which seed was treated with fungicide alone. The second group consists of tests conducted from 1952 through 1954 in which seed was treated with insecticide-fungicide combination treatments applied as dusts or slurries.

1946–48 Tests

Seven field tests and two greenhouse tests were conducted during this period. Seed in all tests was treated wtih a fungicide applied as a dust. Fungicides more extensively tested were Arasan, Phygon, and Phygon XL at dosages of 2.0, 1.5, and 1.0 ounces per bushel of seed, and Spergon at 2.0 ounces per bushel. Other materials tested, but only in one or two tests because they were either inferior to the fungicides mentioned above or were not available for further testing, were Dow

9A, Dow 9B, C and C #224, C and C #640, Zineb, J.W.H., Mycotox, and New Improved Ceresan.

Arasan and Phygon generally were more effective than Spergon in greenhouse tests and in hand-planted field tests. In field plantings, however, where a grain drill was used, Spergon proved to be as effective as Arasan or Phygon, even under conditions favorable for seed decay, such as placement of fertilizer in contact with the seed (Table 9).

Table 9.—Influence of Seed Treatment on Rate of Flow of Pea Seed Through a Force-feed Grain Drill in Field Tests and the Emergence of Strong Plants from Such Treatments, 1948.

Material	Treatment in ounces per bushel	Number of seeds planted per yard of row	Total emergence, per cent		
			Contact placement[a]	Fertilizer drilled ahead[a]	Average
Spergon.	2.0	19	80	86	83
Arasan (50%).	2.0	18	77	81	79
Phygon XL.	1.5	18	77	84	80
None.	—	20	35	46	40
Least difference required for significance					
(19:1).					3
(99:1).					4

[a]200 pounds per acre of 5–10–5.

Unpublished data obtained at this Station[4] in connection with investigations on the relationship between fertilizer applications and the development of pea root rot indicate that seeds well protected with a fungicide can tolerate contact placement of nitrogenous fertilizers, provided that no more than 8 to 12 pounds of total nitrogen per acre are applied in the fertilizer and no rains occur within 48 hours after planting. Present recommendations for New York State call for fertilizer containing 50 pounds of nitrogen per acre. That, together with the unpredictability of the weather, makes it very risky to apply fertilizer in contact with the seed.

Arasan and Phygon, although effective pea seed protectants, possess some undesirable characteristics which have discouraged the general acceptance of these materials for dust treatment of pea seed. The dust of each of these fungicides causes irritation to the skin and mucous membranes of the handlers, particularly if seed is being treated in a poorly ventilated room. Each of these materials when applied to the surface of pea seed increases the friction between seeds so that the rate of delivery of seed through a grain drill is reduced (Table 9). Although this reduction in rate of delivery amounts to only a few seeds per running yard of row, in extensive pea plantings the reduction in rate

[4]Vittum, M. T., and Schroeder, W. T.

of delivery would result in considerable reduction in the number of seeds planted. Furthermore, most of the tests in this retardation of flow were made with only a bushel or two of seed. Prolonged use of a machine with such seed may conceivably increase the retardation and possibly cause some mechanical breakdown among the parts of the present forced-feed grain drills now in use. Spergon is non-irritating to the handler and possesses the advantage of having lubricating properties which permit the ready flow of treated seed through the planter.

1952–54 Tests

Eleven tests were conducted during this period, consisting of two greenhouse plantings and six field plantings in which seed was planted by hand and three extensive field tests in which seed was planted by means of a grain drill. Emphasis in these tests was directed toward the evaluation of Orthocide 75 as a pea seed protectant and toward obtaining information on the practicability of fungicide-insecticide combination treatments for pea seed.

Orthocide 75 as a pea seed protectant

In greenhouse tests, Orthocide 75 proved to be more effective than Spergon in protecting pea seed in soil heavily contaminated with seed-decay organisms. In field tests in which the seed was planted by hand, Orthocide 75 generally was superior to Spergon, particularly under conditions of severe seed decay or when seed susceptible to decay was planted.

Tests conducted in 1953 and 1954 illustrated the relative effectiveness of Orthocide 75 and Spergon as pea seed protectants under severe and moderate seed-decay conditions and with seed varying in susceptibility to decay.

In the early planting in the 1953 tests, under conditions favoring seed decay, Orthocide 75 was more effective than Spergon in protecting seed of Wilt Resistant Surprise (Table 10). In the same test, with Perfected Freezer, which in this test appeared to be more resistant to seed decay than the lot of Wilt Resistant Surprise used, Orthocide 75 and Spergon were equally effective.

In the 1954 tests, total emergence averaged about 80 per cent from untreated seed of Alaska. In the same test, total emergence from Tenex averaged about 49 per cent. With Alaska, treatments with Orthocide 75 and Spergon were equally effective (Table 11). With Tenex, however, Orthocide 75 was slightly superior to Spergon.

In extensive field plantings in which seed was planted by means of a grain drill, Spergon treatments gave results comparable to those from

TABLE 10.—TOTAL EMERGENCE FROM HAND-PLANTED PEA SEED TREATED WITH SPERGON AND ORTHOCIDE 75 ALONE AND IN COMBINATION WITH LINDANE, 1953.

Treatments[a]	Total emergence, per cent	
	Planted April 30	Planted June 12
Wilt Resistant Surprise		
Spergon	59	58
Spergon + lindane	60	64
Orthocide 75	74	61
Orthocide 75 + lindane	66	67
None	8	14
Perfected Freezer		
Spergon	96	79
Spergon + lindane	94	84
Orthocide 75	95	77
Orthocide 75 + lindane	95	83
None	27	34
Least difference required for significance (19:1)	4	9
(99:1)	5	12
Factorial Analyses[b]		
Main factors		
Fungicides		
Spergon	77	71
Orthocide 75	83**	72
Insecticides		
Lindane	79	75**
No lindane	81**	69
Varieties		
Wilt Resistant Surprise	65	63
Perfected Freezer	95**	81**
Interactions		
Fungicides × insecticides	**	NS
Fungicides × varieties	**	NS
Fungicides × insecticides × varieties	**	NS
All other interactions	NS	NS

**Significant at odds of 99:1.
NS = Not statistically significant.
[a]All treatments applied as dusts: Spergon, 2 ounces per bushel; Orthocide 75, 1.5 ounces per bushel; and lindane (75%), 0.33 ounces per bushel.
[b]Does not include untreated seed.

Orthocide 75 on the basis of percentage total emergence (Tables 12 and 13). On the basis of number of plants per acre, unless allowance was made for the retardation of rate of delivery of seed treated with Orthocide 75, Spergon treatment resulted in stands higher in plant population than from Orthocide 75 treatment (Table 13). Even when comparable seeding rates were obtained between Spergon and Orthocide 75, treatments by either adjusting the planter to a wider opening when planting seed treated with Orthocide 75 (Table 12), or by adding a lubricant to the seed treated with Orthocide 75 (Table 13), Spergon treatments were as effective as Orthocide 75 treatments.

TABLE 11.—TOTAL EMERGENCE AND NORMAL PLANTS FROM HAND-PLANTED PEA SEED TREATED WITH SPERGON AND ORTHOCIDE 75 ALONE OR IN COMBINATION WITH EITHER LINDANE OR DIELDRIN APPLIED AS A DUST OR SLURRY, APRIL 20, 1954.

TREATMENTS[a]	TOTAL EMERGENCE, PER CENT				STRONG PLANTS, PER CENT			
	Alaska		Tenex		Alaska		Tenex	
	Dust	Slurry	Dust	Slurry	Dust	Slurry	Dust	Slurry
Spergon	85	89	75	75	71	74	59	60
Spergon + lindane	92	93	76	74	87	89	69	65
Spergon + dieldrin	93	93	77	75	89	90	70	67
Orthocide 75	83	87	81	80	72	76	64	62
Orthocide 75 + lindane	90	92	79	80	87	86	67	71
Orthocide 75 + dieldrin	87	91	81	82	82	87	75	72
Lindane	86	91	49	42	78	83	40	35
Dieldrin	88	86	41	41	82	81	32	31
No treatment	81	80	48	50	65	65	34	33
Least difference required for significance (19:1)		7				7		
(99:1)		9				10		

Factorial Analyses

Main factors	Emergence, per cent	Strong plants, per cent
Fungicides		
Spergon	83	74
Orthocide 75	84	75
None	65	55
Insecticides		
Lindane	78	71
Dieldrin	78	71
None	76	61
Least difference required for significance (19:1)	2	2
(99:1)	3	3
Varieties		
Alaska	88**	80**
Tenex	67	56
Methods		
Dust	77	68
Slurry	78	68
Interactions		
Varieties × fungicides	**	**
Varieties × insecticides	**	**
Varieties × methods	NS	*
Varieties × fungicides × insecticides	NS	**
All other interactions	NS	NS

*Significant at odds of 19:1.
**Significant at odds of 99:1.
NS = Not statistically significant.
[a]Spergon applied at rate of 2 ounces per bushel; Orthocide 75, 1.3 ounces per bushel; lindane (75%), 0.33 ounces per bushel; dieldrin (50%), 0.50 ounces per bushel; Methocel (3%) in slurry treatments at rate of 0.5 pint per bushel.

The influence of Orthocide 75 on rate of delivery of seed through a planter was determined in laboratory and field tests. In the laboratory tests, the rate of delivery of treated seed was determined by weighing the amount of seed delivered in a certain time interval through a

Table 12.—Seeding Rates and Stands of Pea Seed Treated with Spergon and Orthocide 75 in Machine-planted Field Tests in Which the Grain Drill Adjustments Were Varied.

Treatment[a]	Drill setting[b]	Seed planted, lbs.[c]	Seed per acre, lbs.	Number seeds planted per yard of row	Total emergence, per cent[d]
Spergon	22–FS	51	276	29	81
Spergon + lindane	22–FS	50	273	28	79
Orthocide 75	26–FS	52	284	30	79
Orthocide + 75 lindane	26–FS	52	280	29	78
None	22–FS	51	278	29	45
Least difference required for significance					
(19:1)					4
(99:1)					5

[a]Dust treatments: Spergon applied at rate of 2 ounces per bushel; Orthocide 75, 1.5 ounces per bushel; lindane (75%), 0.33 ounces per bushel.
[b]Planter, 15–8 inch row Ontario hoe drill.
[c]In four 200-foot plots, 15 rows in width; variety Perfected Freezer.
[d]Based on calculated number of seeds planted.

Table 13.—Seeding Rate of Pea Seed Treated with Spergon and Orthocide 75 Alone and in Combination with Lubricants in Machine-planted Field Tests in Which the Drill Adjustments Were Maintained Constant.

Treatments[a]	Drill setting[b]	Seed planted		Number seeds planted per yard of row	Total emergence, per cent[d]
		Pounds[c]	Per cent of control		
Spergon	11	38	0	22	73
Orthocide 75	11	34	−11	20	66
Orthocide 75 + graphite	11	39	+3	23	68
Orthocide 75 + HL772	11	35	−7	21	71
No treatment	11	38	—	22	34
Least difference required for significance					
(19:1)					15
(99:1)					21

[a]Rate of application of treatments: Spergon, 2 ounces per bushel; Orthocide 75, 1.5 ounces per bushel; graphite, 1 ounce per bushel; HL772, 12.4 ml. in ¾ pt. 2% Methocel per bushel.
[b]Oliver Superior grain drill.
[c]In four 200-foot plots, 15 rows in width; variety Wilt Resistant Surprise.
[d]Percentage emergence based on calculated number of seeds planted.

section of an Ontario grain drill mounted to a table and driven by an electric motor. In field tests, the rate of delivery was obtained by determining the pounds of seed planted to a known length of plot.

In the laboratory tests, the rate of delivery of pea seed of the variety Perfected Freezer treated with Orthocide 75 was about 20 per cent less than that of seed treated with Spergon and about 13 per cent less than that of the untreated seed (Table 14). In tests with the smaller-seeded variety Wilt Resistant Surprise, the rate of delivery of seed from all treatments was slightly higher than with seed of Perfected Freezer, but

TABLE 14.—RELATIVE RATES OF DELIVERY OF PEA SEED TREATED WITH SPERGON OR ORTHOCIDE 75 ALONE OR IN COMBINATION WITH LINDANE, AND THE PERCENTAGE OF CRACKED SEEDS FROM TREATMENTS AFTER PASSAGE OF SEED THROUGH GRAIN DRILL.

TREATMENTS[a]	VARIETY[b]	RELATIVE RATES OF DELIVERY[c]	NUMBER OF CRACKED SEEDS[d]	
			−Drill	+ Drill
Spergon	PF	104	0	4
Spergon + lindane	PF	102	1	3
Orthocide 75	PF	86	1	6
Orthocide 75 + lindane	PF	87	1	4
None	PF	100	0	3
Spergon	WRS	112	2	2
Spergon + lindane	WRS	105	3	5
Orthocide 75	WRS	92	3	8
Orthocide 75 + lindane	WRS	90	1	6
None	WRS	100	2	6

[a]Dust applications: Spergon applied at rate of 2 ounces per bushel; Orthocide 75, 1.5 ounces per bushel; and lindane (75%), 0.33 ounces per bushel.

[b]PF = Perfected Freezer, 2,270 seeds per pound; WRS = Wilt Resistant Surprise, 2,682 seeds per pound.

[c] $\frac{\text{Grams treated seed delivered}}{\text{Grams untreated seed delivered}} \times 100$

[d]Minus = percentage cracked in 200-seed sample in treated seed lots before passage through grain drill; plus = percentage cracked after passage through grain drill.

again the rate of delivery of seed treated with Orthocide 75 was about 20 per cent less than that of seed treated with Spergon. Passage of the treated seed through the drill resulted in the cracking of a small percentage of the seed. The incidence of cracked seeds in seed lots treated with Orthocide 75 in this test was only slightly greater than that from seed treated with Spergon, although in another experiment with a different seed lot it was higher. Apparently, some seed lots are more apt to crack than others.

In field tests in which seed was planted by means of a grain drill, the rate of delivery of seed treated with Orthocide 75 was about 11 per cent less than that of seed treated with Spergon (Table 13). The addition of lindane dust to either fungicide resulted in a slight reduction in rate of delivery from that of treatment with fungicide alone. The retarding influence of Orthocide 75 on rate of delivery of seed was overcome by adjusting the planter to deliver about 20 per cent more seed than is generally planted with seed treated with Spergon (Table 12), or by adding graphite to Orthocide 75 at the rate of 1 ounce per bushel (Table 13). Even though graphite is an effective lubricant, growers are reluctant to use it because of its dark color and its tenacity to skin and clothing.

Fungicide-insecticide combination treatments

Pea seed treatment tests with a combination of fungicide and insecticide have demonstrated for the most part that protection of pea

seed from both seed-decay organisms and insect injury is of practical value in obtaining a stand of vigorous plants. Although protection of the seed from seed decay by treatment with a fungicide is of prime importance, the incorporation of an insecticide with the fungicide enhances the protective value of the treatments. As in the lima bean seed treatment tests, treatment of pea seed with fungicide-insecticide combination treatment may produce results which vary from test to test, depending upon environmental conditions, variety of seed, and treatments. The interrelationship of all these factors must be considered in interpreting the results of each test.

In 1953, two tests were conducted to determine the effectiveness of treatment of pea seed with Spergon and Orthocide 75 alone, and in combination with lindane. In the early planting seed decay was severe, whereas insect injury was of minor importance. In tests with Wilt Resistant Surprise, the average total emergence from all treated seed was 65 per cent, as compared with only 8 per cent from untreated seed (Table 10). Under identical conditions with Perfected Freezer, the total emergence from all treated seed averaged 95 per cent and 27 per cent from untreated seed. Orthocide 75 was more effective than Spergon in tests with Wilt Resistant Surprise, but with Perfected Freezer each fungicide was equally effective. Treatments with fungicide alone averaged about 2 per cent higher than treatments with insecticide-fungicide combination treatment. Most of this reduction in emergence from insecticide treatment occurred from the Orthocide 75-lindane treatment of seed of Wilt Resistant Surprise.

In the late planting in 1953, stands were reduced as a result of both seed decay and insect injury. Total emergence from all treatments containing an insecticide averaged 6 per cent greater than treatments with fungicide alone (Table 10). Total emergence from seed of Wilt Resistant Surprise averaged 63 per cent and from seed of Perfected Freezer, 81 per cent. Orthocide 75, alone or in combination with lindane, and Spergon was equally effective.

In 1954, tests were conducted to determine the seed protective value of treatments with Spergon and Orthocide alone or in combination with dieldrin or lindane applied either as a dust or slurry to seed of Alaska or Tenex. In tests on Alaska, total emergence from untreated seed averaged about 80 per cent and about 89 per cent from seed treated with a fungicide (Table 11). Spergon and Orthocide 75 were equally effective. Total emergence from treatments with insecticide alone was higher than that from untreated seed. In tests with Tenex, total emergence from untreated seed averaged 49 per cent. Total emergence from treatments containing Spergon averaged about 75 per cent, and

that from treatments with Orthocide 75 averaged about 80 per cent. With Tenex, treatment with insecticide alone reduced stands below that of untreated seed. Treatments containing both fungicide and insecticide averaged about 10 per cent more strong plants than treatments with fungicide alone.

Slurry and dust methods of pesticide application were equally effective with wrinkled-seeded Tenex (Table 11). With smooth-seeded Alaska tested under identical conditions, the slurry method was slightly more effective than the dust application.

In an extensive field planting in which Spergon and Orthocide 75 were applied to pea seed alone, or in combination with Lindane, no apparent effects, beneficial or otherwise, were observed from the addition of the insecticide (Table 12). Insect injury, either in the form of weak plants or reduced stands, was absent in this test.

Pepper Seed Treatment

Pepper seed are similar to tomato seed in that they usually require a disinfectant treatment before applying a seed-protecting fungicide, especially if bacterial spot or anthracnose is suspected of having been present on the seed crop. A mercuric chloride soak (1 ounce in 22.5 gallons of water) for 5 minutes, followed by a thorough rinse, is usually recommended for pepper seed.

In 1947, the materials listed in Table 15 were tested as seed protectants for pepper in a commercial soil known to be heavily infested with seed-decay and damping-off organisms. Arasan at 1.0 per cent by

Table 15.—Protective Value of Various Fungicides on Seed of California Wonder Pepper Planted in a Commercial Plant Grower's Soil, Greenhouse, 1947.

Material	Dosage, per cent by weight of seed	Emergence, per cent	
		Total	Healthy and suitable
MC[a]	std	46	13
MC + Arasan	1.0	88	73
HWT[b]	—	69	38
HWT + Arasan	1.0	93	83
Check	—	65	20
Semesan	1.0	47	11
Dow 9B	1.0	57	26
Arasan	1.0	90	78
N. I. Ceresan	1.0	41	24
Zerlate	1.0	64	25
Phygon	1.0	88	56
Parzate	1.0	92	76

[a]Mercuric chloride soak: 1 ounce mercuric chloride in 7½ gallons of water, soaked for 5 minutes, washed thoroughly, and dried.

[b]Hot water treatment: 122°F (50°C) for 25 minutes.

weight of seed was applied to seed previously treated with mercuric chloride, to seed previously treated with hot water, and to seed receiving no previous treatment. The same seed without the addition of Arasan served as controls. All other fungicides were applied to seed not previously treated with any disinfectant. Two separate experiments were conducted with all the listed materials. The order of response to all of the materials was similar.

Arasan at 1.0 per cent was superior to all of the materials tested, followed by Parzate at 1.0 per cent. All others were inferior under the conditions of the above tests. It is interesting to note that the hot water treatment alone resulted in a higher percentage of healthy seedlings than did the mercuric chloride treatment alone. Whether it is equally as good a disinfectant against seed-borne-diseases was not determined.

Spinach Seed Treatment

Poor stands of spinach are frequently the result of seed decay and pre-emergence damping-off of seedlings. As with beet seed, treatment of spinach seed with a fungicide provides protection against seed decay and pre-emergence damping-off. Stands of spinach are also reduced by the damping-off of seedlings after they have emerged. Seed treatments in current use are of no value in preventing post-emergence damping-off.

During the period 1945–53, 19 different spinach seed treatment tests were conducted. Because of the diversity of materials tested and the different growing conditions experienced through the years, the results of all 19 tests are summarized in Table 16. In this table, the fungicides are rated on the percentage of tests in which a treatment with a particular fungicide resulted in a total emergence numerically greater than that from any of the other treatments. The percentage so determined is designated as the relative value of the treatment.

On the basis of the relative value of the treatments, no material was outstanding, but a variety of materials was moderately effective. Of the organic fungicides in current use, Arasan, Phygon, and Orthocide 75 were the most effective spinach seed protectants. The copper-containing fungicides, COCS and Yellow Cuprocide, were also effective. The low rating of Panogen was due, in part at least, to seed injury.

Stands of spinach are improved by treatment of seed with a fungicide. Spinach plantings in the Geneva area generally result in poor stands because of the tendency of the soil to form a heavy crust which prevents the emergence of seedlings. This soil condition interferes seriously with seed treatment tests, both on spinach and beets.

Poor stands of spinach because of seed decay and damping-off have

TABLE 16.—RELATIVE VALUE OF SPINACH SEED TREATMENTS, 1945–53.

MATERIAL	DOSAGE, PER CENT BY WEIGHT OF SEED	NUMBER OF TESTS	RELATIVE VALUE
Arasan	1.0	14	76
COCS	1.0	5	76
Phygon XL	1.5	7	74
Arasan	1.5	4	73
Orthocide 75	0.5	5	72
C and C No. 224	1.5	4	69
Yellow Cuprocide	1.0	9	68
Arasan SF	1.0	5	67
Orthocide 75	1.0	5	67
Phygon	1.0	10	65
C and C No. 224	1.0	9	65
Zerlate	1.0	6	63
Arasan SF–X	0.75	5	60
Yellow Cuprocide	0.75	14	60
Phygon XL	1.0	6	56
Spergon	1.5	10	43
Panogen[a]	1.0	5	40
Vancide 51	2.25	5	37
Copper sulfate soak[b]	—	5	24
Spergon	1.0	7	21
Dow 9B	1.0	3	20
Zinc oxide	1.5	3	17
No treatment	—	19	10

[a]Plants injured.
[b]Soaked for 1 hour in blue vitrol solution, 2 ounces in 1 gallon of water.

produced a unique problem. As a result of the wide spacing between plants in poor stands, the remaining plants generally grow too large and coarse for a quality product. To overcome this difficulty, some spinach growers, in order to obtain full stands, have resorted to planting spinach seed at heavier rates than necessary in order to compensate for the expected loss of seed to decay and of seedlings to damping-off. Under conditions in which seed decay and damping-off were not severe, most of the seed germinated and developed into healthy seedlings. As a result of the very close spacing of the plants, the area of the lamina of the leaves was decreased considerably without a corresponding decrease in the size of the midribs. Spinach of this type makes an undesirable product. Stem rot also develops more readily in fields with heavy stands. As with beets, there is a definite need for a treatment that will insure good stands of spinach.

Sweet Corn Seed Treatment

During the years 1944–48, 14 different fungicides and combinations thereof were tested on sweet corn seed in 14 different experiments conducted in greenhouse or field soils. Not all materials were included in every test, some being discarded after one or two tests when it be-

came obvious that they were inferior to the standard materials or were no longer available. Among the materials discarded for those reasons were COCS (44 per cent Cu); combinations of COCS with Semesan Jr., Spergon, and Arasan; Dow 9A; Mycotox; C & C 224; and C & C 406.

The more promising materials, Spergon, Semesan Jr., Arasan, Barbak C, Phygon, and Dow 9B, were included in the majority of the tests. The relative value of the more promising materials was determined by the percentage of tests in which the normal plants of any single treatment were numerically greater than those for any other treatment. In

Table 17.—Relative Value of Fungicidal Seed Protectants, Alone and Combined with Insecticides, for Sweet Corn, Based on Total Plant Emergence.

Material	Dosage, ounces per bushel	Number of tests	Value
1944–48 (No Insecticide)			
Arasan (50%)	2.0	12	92
Arasan (50%)	1.0	11	57
Phygon	2.0	11	81
Phygon	1.0	8	67
Barbak C	2.0	4	44
Dow 9B	2.0	11	41
Semesan Jr	2.0	10	40
Spergon	2.0	13	36
None	—	13	0
1949–54 (Combined with Insecticide)			
Arasan SF–X	1.3	2	100
Arasan SF	1.3	6	77
Phygon	1.5	4	45
Orthocide 75	1.3	6	81
Spergon	2.0	4	41
Vancide 51	5.0	2	29
CPI–2	2.3	2	36

these tests, all fungicide treatments produced a greater number of normal plants than the nontreated controls. On that basis, Arasan and Phygon were best among the above fungicides even when used as dosages as low as 1 ounce per bushel (Table 17).

Effectiveness of fungicide treatment on seed planted in soil maintained at different temperatures

A single test was conducted to determine the effectiveness of fungicide treatments on seed of Ioana planted in soil maintained at different temperatures. The seed was planted in flats containing contaminated soil and the flats placed in a chamber maintained at the desired temperature. The fungicides tested were Arasan, Spergon, Semesan Jr., and COCS (44 per cent). The results of this test are graphically illustrated in Fig. 1.

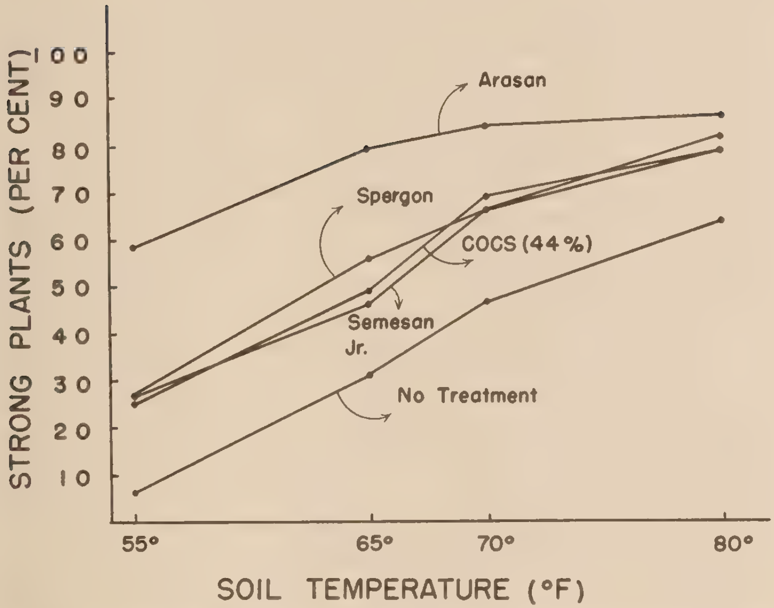

Fig. 1.—The relationship of soil temperature to the performance of various fungicides against seed decay in Ioana sweet corn.

At a soil temperature of 55°F, the number of strong plants, on the basis of seeds planted, averaged 6 per cent from the untreated seed, 26 per cent from seed treated with Spergon, COCS, or Semesan Jr., and 58 per cent from seed treated with Arasan. At a soil temperature of 65°F, the number of strong plants from untreated seed averaged 31 per cent, from seed treated with COCS about 48 per cent, from seed treated with Semesan Jr., 46 per cent, from seed treated with Spergon about 56 per cent, and from seed treated with Arasan 79 per cent. At soil temperatures of 70° and 80°F, the differences in performance between treatments became smaller than at the lower temperatures, but at all temperatures Arasan proved to be the most effective. The effectiveness of Arasan at low soil temperatures is of particular importance since in early plantings of corn, the soil temperature is within the low range of temperatures of this test.

Fungicide-insecticide combination treatments

During 1952–54, six sweet corn seed treatment tests were conducted in which fungicides were tested alone or in combination with an insecticide. The relative effectiveness of the fungicides, whether alone or in combination with an insecticide, was determined by calculating the

percentage of tests in which total emergence from any treatment was numerically greater than that of any other treatment. On the basis of the relative value of the different fungicides included in these tests, Arasan was the most effective followed by Orthocide, Phygon, and Spergon in descending order of effectiveness (Table 17).

Corn seed is not as subject to seed decay and to maggot injury as bean seed. Furthermore, insect injury to corn is not as readily observed as is insect injury to bean seed. For these reasons, the benefits from combination fungicide-insecticide treatments are not as apparent on corn seed as on bean seed. Fungicide-insecticide combination treatments of corn seed conducted from 1952 to 1954 have provided evidence that the treatments may not necessarily increase the percentage emergence but do result in an increase in the percentage of vigorous seedlings.

Corn seed treatment tests carried out in 1953 are representative of other tests conducted during this period. Seed of Golden Crown was treated on May 6 with Spergon, Arasan, Orthocide 75, or Phygon alone or in combination with Lindane. Each treatment was applied as a dust and a slurry. The seeds were hand-planted on May 7 and the total number of plants and the number of normal plants were counted on June 2.

Seed decay and insect injury, although not severe in this test, were sufficient to indicate the beneficial effect of the combination treatments. Each of the fungicide treatments resulted in a greater percentage of normal plants than from seed not treated with a fungicide (Table 18). Also, the percentage of plants from treatments containing an

TABLE 18.—THE EMERGENCE OF NORMAL PLANTS OF SWEET CORN FROM SEED TREATED WITH FUNGICIDES ALONE OR IN COMBINATION WITH LINDANE, APPLIED EITHER AS DUSTS OR SLURRIES.

Fungicide[a]	Normal plants, per cent				
	No Lindane		Lindane		Fungicide, average
	Dust	Slurry	Dust	Slurry	
Spergon	82	89	91	90	88
Arasan	83	86	92	90	88
Orthocide 75	84	85	91	90	88
Phygon	80	84	90	85	85
None	71	77	86	80	78
Insecticide average	82**		89		
Least difference required for significance			All treatments		Fungicides
(19:1)			6		3
(99:1)			8		4

**Significant at odds of 99:1.

[a]Spergon, 2.0 ounces per bushel; Arasan dust (50%), 2.0 ounces; Orthocide 75, 1.3 ounces; Phygon, 1.5 ounces; Arasan SF-X, 1.3 ounces; Lindane (75%), 0.33 ounces; slurry, 4% Methocel, applied at ½ pint per bushel.

insecticide was significantly greater than from treatments lacking an insecticide. Differences in percentage normal plants between fungicides were not significant. Differences between dust and slurry methods of pesticide application were not significant.

Tomato Seed Treatment

In New York State tomato plants for field setting are generally grown from seed planted in the greenhouse in flats of composted soil. After a time the seedlings are pricked into flats of soil and kept in cold frames until it is time to set them in the field. The hot water treatment of seed as a disinfectant is recommended, but that does not protect the seed from pre-emergence damping-off in the soil. It is necessary, therefore, to treat the seed with a protectant fungicide. Other measures, such as soil pasteurization and soil drenches, are also used to supplement seed treatment, but they do not fall within the scope of seed treatments.

During the years 1944 through 1947, nine different experiments with tomato seed were conducted with a number of the leading seed protectants. In some of these tests, as many as six different commercial compost soils were used in each experiment. The effectiveness of the materials was measured by data taken on total emergence, the number of plants healthy and suitable for pricking, and the rate of seedling emergence. Typical of these tests, are the data in Table 19, which represent the combined analysis of two separate experiments involving 12 treatments planted in six different commercial compost soils. Each treatment consisted of 200 seeds planted in each of six replicates. The soils ranged from pH 5.5 to 7.2 and the soluble salt content varied from a specific conductivity of 50 to 130 $\times$ 10^{-5}. Under such a wide range of soil conditions, the treatments were of the same order and no significant interactions between them and the soils were found.

Of the materials tested only Semesan resulted in a materially lower total emergence, which is somewhat puzzling since the same material, when used as a soil drench, is very effective against post-emergence damping-off. The percentage of plants free of damping-off lesions and of suitable size for pricking is the best measure of the effectiveness of any single material. On that basis, only Arasan and Parzate were outstandingly good. New Improved Ceresan was almost as effective as a soak but was ineffective as a dust application. The use of this material on tomatoes in New York State presents problems. In most other states, it is recommended as a disinfectant and protectant, formerly as a soak but more recently as a dust. It can be seen from Table 19 that it is quite ineffective as a dust treatment. As a soak it is a good protectant, but experiments conducted in sterile quartz sand and pasteurized soil

TABLE 19.—EFFECT OF TWELVE DIFFERENT SEED TREATMENTS IN SEVEN DIFFERENT SOILS ON STAND OF TOMATO SEEDLINGS, GENEVA, 1947.

MATERIAL	DOSAGE, PER CENT BY WEIGHT	EMERGENCE, PER CENT: Test No. 1		Test No. 2		Average		Sand[b]
		Total	H and S[a]	Total	H and S[a]	Total	H and S[a]	
Parzate..........	1.5	84	72	78	69	81	70	81
Yellow cuprocide..	1.5	74	30	79	48	76	39	85
None[c]...........	—	40	5	49	14	44	9	84
Arasan..........	1.0	85	68	84	66	84	67	87
Arasan..........	1.5	86	71	83	73	85	72	89
Semesan.........	1.5	64	17	61	28	63	23	85
Zerlate..........	1.5	80	53	79	62	79	58	86
N. I. Ceresan (dust)	0.5	76	40	80	59	78	49	86
N. I. Ceresan soak.	std	77	65	74	62	76	63	60
N. I. Ceresan soak[c]	std	78	65	79	65	78	65	80
$CuSO_4$ soak......	std	81	39	79	48	80	44	88
None............	—	45	11	48	17	46	14	86
Least difference required for significance (19:1).......		7	8	6	7	7	8	9

[a]H and S = Healthy and suitable for pricking into flats, i.e., free of any damping-off lesions.
[b]Washed sand containing no seed-decay or damping-off organisms.
[c]Seed not hot water-treated; all others hot water-treated at 122°F (50°C) for 25 minutes.

indicate that it delays emergence 4 to 5 days beyond that of other seed treatments. When seed previously treated with New Improved Ceresan is subsequently treated with Arasan, severe injury and low stands result, especially in light sandy soil. That fact makes it imperative that growers intending to use Arasan make doubly certain that the seed has not been treated previously with a mercurial, such as New Improved Ceresan.

Discussion of Better Treatments

The experiments reported in this bulletin were designed primarily to keep pace with the newly introduced and supposedly more effective fungicides and to compare them with older and more established materials. By that procedure it was hoped to determine, if possible, a more effective seed treatment for the vegetable crops listed.

For various reasons, a complete evaluation of all available materials was not always possible. In many instances, experiments were modified to consider other factors. Environmental conditions were not always conducive to clear-cut differences among materials and the controls. Nevertheless, it is believed that the data obtained provide sufficient background for a discussion of the better treatments.

It would be inadvisable to make an absolute recommendation of any one material for a given crop. Actually, with many crops, several materials or treatments can be used with the assurance that each is

effective from a practical standpoint. A discussion of the better treatments and the factors which may modify their use follows for each vegetable or group of vegetables.

Bean Seed

All types of bean, lima, snap, or dry, respond favorably to the fungicide-insecticide combination treatment. Some, particularly the Fordhook lima bean, show a greater response than others. Although the treatment protects the seed against adverse germinating conditions, there is a limit beyond which it will not be practical. The greatest limitations are low temperature and wet soil. These occur in extremely early plantings. Usually, soil temperatures below 55°F so delay germination that the protectants are relatively ineffective, especially if wet soil conditions develop immediately after planting.

Thiram (Arasan SF-X, 75 per cent) or captan (Orthocide, 75 per cent) at 1.3 ounces per bushel, combined with either lindane (75 per cent) at 0.3 ounce or dieldrin (50 per cent) at 0.5 ounce per bushel (or equivalent amounts of active toxicants) suspended in enough 2 per cent Methocel to give ½ pint of slurry for each bushel of seed has given the most satisfactory protection to date. Commercial formulations, such as Delsan, I and D, GLF Combination Treatment, and Ortho Seed Guard, which contain either of the above combinations, have performed equally as well.

The seed coats of some varieties of bean wrinkle if more than ½ pint of slurry is added per bushel. In general, dry dust applications of the above pesticides are not as effective as slurries, although good results have been obtained under some conditions. Seeds, either treated or untreated, are weakened, especially Fordhook limas, by exposure to high temperatures in the neighborhood of 80° to 90°F, or above, even when exposed for a relatively short period of 9 days. The effect is on the seed, not on the protective value of the pesticide. Combination treatments of lindane or dieldrin with Arasan retained the same pesticidal properties 32 months, 14 of which were at high temperatures, after storage as freshly treated seed that had undergone the same storage in the untreated condition.

Beet Seed

Beets are subjected to seed decay and pre-emergence and post-emergence damping-off. Seed protectants have given good control of seed decay and pre-emergence damping-off, but offer little help against post-emergence damping-off. The latter disease initiates a dry rot and deformation of the beet which usually is not noticed until harvest or

storage. Soil application of fungicides, either as dusts or sprays, have not been too successful against this phase of damping-off, but further research is in progress.

As seed protectants, dichlone (Phygon) at 0.5 to 1.0 per cent, captan (Orthocide, 75 per cent) at 1.0 per cent, and Vancide 51 at 3.0 per cent by weight of seed were the best materials. Dichlone (Phygon) consistently appeared at the top. Thiram (Arasan, 50 per cent) at 1.0 per cent was less effective than the aforementioned materials.

Carrot Seed

Carrot stands are not always improved by seed protectants. Nevertheless, it is good insurance to treat the seed in the event of bad planting conditions and the cost of the treatment is relatively low.

The outstanding protectants were dichlone (Phygon) at 0.5 to 1.0 per cent, thiram (Arasan, 50 per cent) at 1.0 per cent, and Ceresan M at 0.5 per cent by weight of the seed. Captan was not tested.

Crucifer Seed

Cabbage, cauliflower, and broccoli are the crucifers commonly used for processing. All of them are susceptible to black rot and blackleg, seed-borne diseases, and for that reason the seed should be hot water-treated and dried before a protectant fungicide is applied. Cauliflower and broccoli are treated in water held at 122°F (50°C) for 20 minutes, cabbage for 25 minutes.

Of the protectants tested, thiram (Arasan, 50 per cent) dust at 0.5 to 1.0 per cent by weight of seed gave the best total emergence and the cleanest plants in commercial plant growing soil. Zineb (Parzate) at 0.5 per cent and ziram (Zenate) at 1.0 per cent were somewhat less effective. All other materials were ineffective.

Cucurbit Seed

The cucurbits are frequently treated with mercuric chloride soak (1 ounce of mercuric chloride in 7.5 gallons of water) for 5 minutes, washed thoroughly, and dried. This is a disinfectant treatment to control angular leaf spot and anthracnose, both of which may be seed-borne. In recent years, less and less seed is so treated, especially if the seed crop is free of the above diseases. In spite of the thorough washing, the mercurial is difficult to wash off, and the residue reacts with certain seed protectants, resulting in poor stands of distorted seedlings. In the tests reported in this bulletin, only cucumber (variety National Pickling) showed pronounced injury, but reports of other workers indicate that varieties of squash, watermelon and other cucurbits are also

injured. Hot water treatment, 122°F (50°C) for 25 minutes, has been applied to seeds of cucurbits with no apparent reduction in germination, but its effect on seed-borne pathogens is not known.

Thiram (Arasan, 50 per cent) at 0.25 to 0.50 per cent by weight of seed and dichlone (Phygon) at 0.125 to 0.250 per cent were the most effective protectants tested, but only on seed not previously treated with the mercuric chloride soak. When the seed was treated with the mercurial disinfectant, only thiram produced a normal stand. For the present, therefore, it would be advisable to use only thiram on cucurbit seed previously disinfected with mercuric chloride. The effect of captan on such cucurbit seed has not been investigated.

In recent years, some cucurbit seed, notably squash and pumpkin, have been successfully treated with the fungicide-insecticide combination used on bean seed. Thiram (Arasan SF-X, 75 per cent) or captan (75 per cent) at 1.3 ounces combined with 0.3 ounces of Lindane (75 per cent) or 0.5 ounces of dieldrin (75 per cent) per bushel of seed (28 pounds) have been satisfactory. The above amounts cover the spongy seed coats better if they are made up in 1 pint of 2 per cent Methocel slurry instead of one-half pint as for beans. Dust applications may be just as effective, but this has not been determined experimentally.

Pea Seed

The choice of a protectant for pea seed presents problems. Unfortunately, the fungicides which gave the best protection under adverse conditions when planted by hand in field plots did not necessarily perform any better than the standard Spergon treatment when planted under commercial planting conditions in the field with the force-feed grain drills presently used. Captan (Orthocide, 75 per cent) dichlone (Phygon XL), and thiram (Arasan, 50 per cent) performed better than chloranil in hand-planted field plots or in greenhouse soil under severe seed decay conditions. When seed treated with these materials is planted commercially with a grain drill, the rate of flow is retarded so that as much as 20 per cent less seed is drilled per acre as a given drill setting. Furthermore, it has been observed that cracking of the seeds can be increased, depending a lot on the condition of the seed. Some of them are more irritating to the skin and mucous membranes of certain individuals than chloranil. The retarded rate of flow can be overcome by adding 1 ounce of graphite with the materials for each bushel. It can also be corrected by increasing the drill setting. Neither of these methods, however, have increased the percentage emergence over that obtained with Spergon-treated seed in the tests conducted, which were under rather severe seed decay conditions.

It would appear from the results obtained and presented in this bulletin that the use of Spergon at 2 ounces per bushel will, under most commercial planting conditions, produce as satisfactory a stand as any other material with a minimum of seeding difficulties. Materials such as captan (75 per cent), thiram (50 per cent) or dichlone at 1.3, 2,0, and 1.5 ounces per bushel, respectively, can be used, but it is advisable to add graphite at 1 ounce per bushel of seed with each of these materials, or increase the drill setting. It is well to caution the reader that it is not known what continued use of such treated seed day after day in the same drill would have on the germinability of the seed or the condition of the drill parts. Perhaps the development of a new type of pea planter will eliminate the above problem.

The use of the fungicide-insecticide combination was also tried on pea. Such a combination proved more effective than the fungicide alone when insect pests were active. The effect was most pronounced in strong plants rather than in total stand. In the absence of soil insect activity, the combination treatments behaved similarly to the fungicide alone, except under conditions of severe seed decay in which instance the combination treatments were only slightly less effective. Treatment of seed with an insecticide alone, however, can reduce the stand considerably, sometimes below that of untreated seed. There was no indication that dust applications of the combination treatments were less effective than the slurry application.

In combination treatments, the insecticides lindane (75 per cent) at 0.3 ounces and dieldrin (50 per cent) at 0.5 ounce per bushel were effective when combined with the aforementioned fungicides for pea.

Pepper Seed

Pepper seeds are treated with a mercuric chloride soak (1 ounce in 22.5 gallons of water for 5 minutes, rinse well, and dry) only if bacterial spot or anthracnose is suspected of having been present on the seed crop. It is not definitely known if a hot water treatment, 122°F (50°C) for 25 minutes, will accomplish the same effect, but the treatment is not injurious to pepper seed.

As protectant fungicides thiram (Arasan, 50 per cent) at 1.0 per cent by weight of seed was superior to all others. Zineb (Parzate, 78 per cent) at 1.0 per cent by weight was almost as effective. All other materials were ineffective. Captan was not included in the tests.

Spinach Seed

Spinach is similar to beet in that the post-emergence phase of damping-off is equally as important as pre-emergence or seed decay. Some

method other than seed treatment will have to be developed to control it. The need for such a control is urgent because growers have a tendency to seed heavy to compensate for the later development of damping-off. When it does not occur, the stands are too thick and very often stem rots develop at harvest time.

A number of materials are quite effective protectants against seed decay. Copper fungicides, such as Yellow Cuprocide at 0.75 per cent and COCS at 1.0 per cent by weight of seed, were very effective. Of the organic fungicides, thiram (Arasan, 50 per cent) at 1.0 per cent, dichlone (Phygon) at 1.0 to 1.5 per cent, and captan (Orthocide, 75 per cent) at 1.0 per cent by weight of seed were equally as effective.

Sweet Corn Seed

Sweet corn is another vegetable crop that responds to the combination seed treatment of a fungicide and an insecticide. The benefits from such a treatment usually appear as a greater stand of more uniform and vigorous plants. The low cost per acre for such a treatment represents an inexpensive investment for maximum protection of expensive seed.

Of the fungicides tested on sweet corn, thiram (Arasan SF-X, 75 per cent) at 1.3 ounces, thiram (Arasan, 50 per cent) at 2.0 ounces, captan (Orthocide, 75 per cent) at 1.3 ounces, and dichlone (Phygon XL) at 1.5 ounces per bushel appear to be equally effective, with a slight edge going to thiram because of its excellent performance over a wide range of planting conditions. The above fungicides, when combined with lindane (75 per cent) at 0.3 ounce or dieldrin (50 per cent) at 0.5 ounce per bushel provide excellent protection against both seed decay and soil insect injury. On sweet corn they may be applied as slurries or dusts. Commercial formulations such as Delsan, I and D, GLF Combination Treatment, and Ortho Seed Guard, when used according to manufacturer's directions, have performed equally as well as the above combinations.

Tomato Seed

Tomato seed should be treated with hot water held at 122°F (50°C) for 25 minutes and then dried before adding a seed protectant. In some states, New Improved Ceresan and other mercurials are applied to tomato seed for disinfectant purposes instead of the hot water treatment, but they are not recommended in New York State.

As seed protectants against seed decay and damping-off, thiram (Arasan, 50 per cent) at 1.0 per cent by weight of the seed and zineb (Parzate, 78 per cent) at 1.5 per cent were the best of the materials

tested. Captan was not included in these tests. As a precaution, it should be pointed out that the application of thiram to seed previously treated with a mercurial, such as is done in some states, results in very severe injury and death of seeds. For that reason, growers should be certain that the seed was not previously treated with a mercurial before adding thiram. Mercurials such as New Improved Ceresan were not satisfactory protectants in the tests conducted.

Acknowledgements

The writers gratefully acknowledge the cooperation of Associated Seed Growers, New Haven, Conn.; F. H. Woodruff & Sons, Milford, Conn.; Crites-Moscow Growers, Moscow, Idaho; and Curtice Brothers Co., Rochester, N. Y., for supplying seed and land for some of the experiments. They also express their thanks to the pesticide manufacturers for supplying materials.